Translation

Imaging System

This invention relates to an imaging system, especially an imaging system for imaging electromagnetic radiation in the optical spectral range, comprising at least one lens element and at least one first and one second optically functional boundary surface through which the electromagnetic radiation can pass, and at least the first and at least the second optically functional interface can be located either on one or on two or more lens elements, at least the first and at least the second optically functional interface having at least in sections a cylinder lens geometry or a cylinder lens-like geometry so that these optically functional interfaces each have a direction which lies in the interfaces and along which at least in sections the curvature of the surface is essentially constant, the direction of essentially constant curvature of at least the first optically functional interface to the direction of essentially constant curvature of at least the second optically functional interface being aligned roughly perpendicular to one another.

An imaging system of the aforementioned type is known from US patent US 5,844,723. The imaging system described therein is used for focussing the light emerging from the laser diode onto the entry surface of the optical fiber. To do this two cylinder lenses are used with cylinder axes which are perpendicular to one another. The disadvantage in this system is that the imaging

errors which occur due to the two cylinder lenses which are crossed to one another cannot be compensated.

The object of this invention is to devise an imaging system of the initially mentioned type in which imaging errors can be largely avoided.

This object is achieved by the features of claims 1 and 5. As claimed in claim 1 it is provided that at least the first and/or at least the second optically functional interface have an aspherical cylinder lens geometry or an aspherical cylinder lens-like geometry. The aspherical cylinder lens geometry can be formed for example by an elliptical or hyperbolic or parabolic cylinder section. By choosing the aspherical cylinder lens geometries for the optically functional interfaces of the lens elements the difference of optical path lengths of the electromagnetic radiation passing through the imaging system is minimized so that planar wave fronts are present after passing through the imaging system.

Imaging systems as claimed in the invention can be used for the entire optical spectral range from the vacuum-UV range into the far infrared range. It is also conceivable as claimed in the invention to use imaging systems as claimed in the invention in the x-ray range as long as the imaging takes place by refractive optically active interfaces.

It is possible as claimed in the invention for there to be at least two lens elements, on one of the lens elements there being the first optically functional interface and on the other of the lens elements the second optically functional interface.

It is also possible to provide each of the lens elements with two optically functional interfaces, then for example for each of the lens elements the optically functional interfaces opposite one another having cylinder lens geometries with directions of essentially constant curvature, i.e. with cylinder axes which are perpendicular. Alternatively it is also possible to make each of the lens elements such that there are one first or second optically functional interface and one planar inlet and outlet surface opposite it at a time.

In addition or alternatively to the embodiment of the cylinder lens geometries of the first and the second optically active interface as aspherical cylinder geometries, as claimed in claim 5 there is the possibility of providing an additional correction element with at least a third optically functional interface which likewise has at least in sections a cylinder lens geometry or cylinder lens-like geometry so that this interface has a direction which lies in the surface along which at least in sections the curvature of the surface is essentially constant. By means of this additional correction element likewise imaging errors can be eliminated so that the corresponding wave fronts of the electromagnetic radiation passing through the imaging system are corrected or converted into planar wave fronts.

According to one preferred embodiment of this invention the direction of essentially constant curvature of at least the third optically functional interface is aligned at an angle of roughly 45° to the directions of essentially constant curvature of at least the first and at least the second optically functional

interfaces. In this alignment of at least the third optically functional interface of the correction element the imaging errors which are produced by the first and second optically functional interfaces which are for example perpendicular to one another and which are provided with a spherical cylinder geometry can be for the most part corrected. Advantageously it can be provided that the correction element has two third optically functional interfaces opposite one another with directions of essentially constant curvature perpendicular to one another and are aligned preferably at an angle of roughly 45° to the direction of essentially constant curvature of the first and the second optically functional interfaces. Here the third optically functional interfaces can be made concave.

As claimed in the invention it is possible to provide at least the third optically functional interface with a spherical or an aspherical cylinder lens geometry. Especially for an aspherical cylinder lens geometry of at least the third optically functional interface of the correction element can the imaging errors caused by the two lens elements be optimally corrected. The aspherical cylinder lens geometry can in turn be formed for example by an elliptical, hyperbolic or parabolic cylinder lens section.

It is possible to arrange the two lens elements and especially in addition the correction element on a common carrier. One such compact embodiment of the imaging system as claimed in the invention can be used for example to focus the

light emerging from a laser diode onto the entry surface of an optical fiber.

It is also possible to use the imaging system as claimed in the invention, for example in the form of an imaging system housed on a common carrier as a microobjective lens which can be designed as claimed in the invention to have a very wide angle.

In objective lenses with a very wide angle under certain circumstances, as a result of the correction of imaging errors which is very effective as claimed in the invention, angles of more than 90° can be achieved with relatively good quality.

Here, under certain circumstances it can be especially advantageous, instead of lens elements, to use arrays or linear lines of especially identical lens elements. In addition, instead of correction elements, arrays or linear lines of especially identical correction elements can be used. Here it is especially advantageous that by using cylinder lenses or cylinder lens-like geometries rectangular or square lens elements and correction elements can be used so that arrays or linear lines of lens elements or correction elements with much better space utilization or with maximum attainable packing density can be prepared. These linear lines or two-dimensional arrays of lens elements and optically correction elements can be used for CCD cameras or CMOS cameras. It is also especially possible to use these imaging systems for process observation, for example for observation of welding processes.

Other advantages and features of this invention become apparent from the following description of preferred embodiments with reference to the attached figures.

Figure 1a shows a side view of one embodiment of a imaging system as claimed in the invention;

Figure 1b shows a plan view of the imaging system as shown in Figure 1a;

Figure 1c shows a view along arrow Ic in Figure 1a;

Figure 2 shows perspective view of a correction element of the imaging system as shown in Figure 1;

Figure 3a shows a schematic of another embodiment of the imaging system as claimed in the invention;

Figure 3b shows a plan view of the imaging system as shown in Figure 3a.

First, reference is made to Figure 1. The embodiment of the imaging system as claimed in the invention shown therein comprises two lens elements 1, 2 which are mounted on a carrier 3 essentially parallel to one another and spaced apart from one another. Between the two lens elements in the embodiment shown there is a correction element 4 which is likewise aligned essentially parallel to the two lens elements 1, 2 and is likewise mounted on the carrier 3. With the imaging system given by the two lens elements 1, 2 and the correction element 4, for example the light emerging from the laser diode 5 which is shown in Figure 1 can be focussed on a small space sector which is located in Figure 1a and Figure 1b in the right-hand part and

which corresponds for example to the entry surface of an optical fiber.

The lens element 1 on its side which is the left side in Figure 1a and 1b has a planar entry surface 6 and on its right side an optically functional interface 7. Accordingly the second lens element 2 on its left side has a planar entry surface 8 and on its right side an optically functional interface 9. In the embodiment shown, the first and the second optically functional interface 7, 9 in sections have a cylinder lens geometry, in the embodiment shown the cylinder lens geometry being formed by a cylinder section with a cross section with the shape of a sector. The two cylinder axes of these cylinder sections of the first and second optically functional interfaces 7, 9 are perpendicular to one another in the embodiment shown.

It is possible, instead of the spherical cylinder geometries, to use aspherical cylinder geometries for the first and the second optically functional interface 7, 9. In this way imaging errors which form in imaging with cylinder lenses crossed to one another are effectively compensated. In the embodiment shown, this compensation is furthermore undertaken by the additionally inserted correction element 4 which has the third optically functional interfaces 10, 11 which comprise one cylinder section 12, 13 at a time, as is apparent from Figure 2. These cylinder sections 12, 13 of the optically functional interfaces 10, 11 of the correction element 4 are perpendicular to one another in the embodiment shown and at an angle of 45° to the cylinder axes of the optically functional interfaces 7, 9.

It is possible to provide the optically functional interfaces 10, 11 of the correction element 4 with a spherical or aspherical cylinder lens geometry. For example elliptical, hyperbolic or parabolic cylinder geometries can be used as aspherical geometries.

Figure 3 shows one embodiment of the imaging system as claimed in the invention which can be used as the objective lens. Here the light 15 emerging from the object 14 after passing through an aperture diaphragm 16 is imaged by two lens elements 17, 18 followed by one correction element 19 in the imaged embodiment. The light emerging from the correction element 19 in Figure 3 on the right side can for example strike a CCD sensor element or CMOS sensor element.

In the embodiment shown in Figure 3, each of the lens elements 17, 18 both on its entry and also its exit side has an optically functional interface with a cylinder lens geometry or cylinder lens-like geometry. As in the embodiment shown in Figure 1 and Figure 2 this cylinder lens geometry or cylinder lens-like geometry can be chosen as a spherical or aspherical cylinder lens geometry. In the embodiment shown the two optically functional interfaces of each of the lens elements 17, 18 are each provided with cylinder lens geometries which are perpendicular to one another. Furthermore, in the embodiment shown the correction element 19 is provided with an optically functional interface with a cylinder lens geometry only on its entry surface. On its exit surface the correction element 19 is planar in the embodiment shown.

As claimed in the invention it is possible to combine the imaging systems shown in FIgure 3 for example which consist of two lens elements 17, 18 and optionally a correction element 19 and optionally an aperture diaphragm 16 into lines or arrays so that they can be assigned to linear lines of camera sensors or two-dimensional fields of camera sensors.